

DRAFT

Grade 6–8 Earth Science

Item Specifications

Updated February 2020



Table of Contents

Introduction	3
Earth and Space Sciences	4
Earth's Place in the Universe	4
ESS1.A	4
ESS1.B	15
ESS1.C	18
Earth's Systems	21
ESS2.A	21
ESS2.B	27
ESS2.C	29
Earth and Human Activity	39
ESS3.A	39
ESS3.B	42
ESS3.C	45
ESS3.D	50
Engineering, Technology, and Application of Science	52
ETS1.A	52
ETS1.B	54

Grades 6-8 SCIENCE

Introduction

In 2014 Missouri legislators passed House Bill 1490, mandating the development of the Missouri Learning Expectations. In April of 2016, these Missouri Learning Expectations were adopted by the State Board of Education. Groups of Missouri educators from across the state collaborated to create the documents necessary to support the implementation of these expectations.

One of the documents developed is the item specification document, which includes all Missouri grade level/course expectations arranged by domains/strands. It defines what could be measured on a variety of assessments. The document serves as the foundation of the assessment development process.

Although teachers may use this document to provide clarity to the expectations, these specifications are intended for summative, benchmark, and large-scale assessment purposes.

Components of the item specifications include:

Expectation Unwrapped breaks down a list of clearly delineated content and skills the students are expected to know and be able to do upon mastery of the Expectation.

Depth of Knowledge (DOK) Ceiling indicates the highest level of cognitive complexity that would typically be assessed on a large scale assessment. The DOK ceiling is not intended to limit the complexity one might reach in classroom instruction.

Item Format indicates the types of test questions used in large scale assessment. For each expectation, the item format specifies the type best suited for that particular expectation.

Content Limits/Assessment Boundaries are parameters that item writers should consider when developing a large scale assessment. For example, some expectations should not be assessed on a large scale assessment but are better suited for local assessment.

Sample stems are examples that address the specific elements of each expectation and address varying DOK levels. The sample stems provided in this document are in no way intended to limit the depth and breadth of possible item stems. The expectation should be assessed in a variety of ways.

Possible Evidence indicates observable methods in which a student can show understanding of the expectations.

Stimulus Materials defines types of stimulus materials that can be used in the item stems.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS1.A.1
Core Idea	Earth's Place in the Universe	
Component	The Universe and its Stars	
MLS	Develop and use a model of the Earth-sun-moon system to explain the cyclic patterns of lunar phases and eclipses of the sun and moon.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to explain the cyclic patterns of lunar phases and eclipses of the sun and moon. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The Universe and Its Stars</p> <ul style="list-style-type: none"> Patterns of the apparent motion of the Sun, moon, and stars in the sky can be observed, described, predicted, and explained with models. <p>Earth and the Solar System</p> <ul style="list-style-type: none"> This model of the solar system can explain eclipses of the sun and the moon. Earth's axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth throughout the year. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Patterns</p> <ul style="list-style-type: none"> Use patterns to identify cause and effect relationships between the relative positions of Earth, the moon, and the Sun and the cyclic patterns of lunar phases and eclipses of the sun and moon. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should not include:
 - Memorization of moon phases or eclipses as in fill in diagrams

Possible Evidence

Observable features of the student performance by the end of the course:

- Components of the model
 - To make sense of a given phenomenon involving, students develop a model (e.g., physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including:
 - Earth, including the tilt of its axis of rotation.
 - Sun.
 - Moon.
 - Solar energy.
 - Students indicate the accuracy of size and distance (scale) relationships within the model, including any scale limitations within the model.
- Relationships
 - In their model, students describe* the relationships between components, including:
 - Earth rotates on its tilted axis once an Earth day.
 - The moon rotates on its axis approximately once a month.
 - Relationships between Earth and the moon:
 - The moon orbits Earth approximately once a month.
 - The moon rotates on its axis at the same rate at which it orbits Earth so that the side of the moon that faces Earth remains the same as it orbits.
 - The moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun.
 - Relationships between the Earth-moon system and the sun:
 - Earth-moon system orbits the sun once an Earth year.
 - Solar energy travels in a straight line from the sun to Earth and the moon so that the side of Earth or the moon that faces the sun is illuminated.
 - Solar energy reflects off of the side of the moon that faces the sun and can travel to Earth.
 - The distance between Earth and the sun stays relatively constant throughout the Earth's orbit.

Sample Stems

A student noticed that the Moon's appearance seemed to change from night to night. They decided to check the library for more information about the Moon's appearance. The student discovered the following information: Figure 1 shows a model of the Sun, Earth and Moon. Figure 2 shows some of the different appearances of the Moon and the name of each of these phases.

Figure 1.
Movement of Earth and the Moon

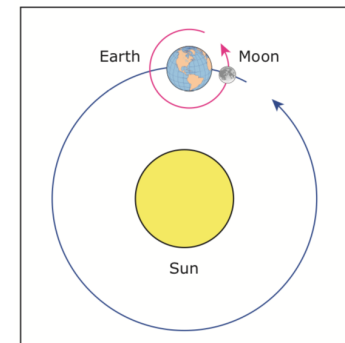
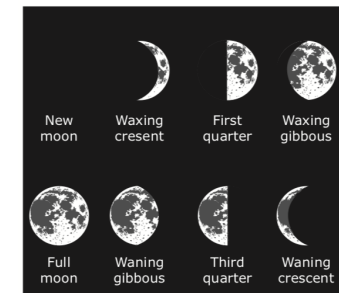


Figure 2.
Phases of the Moon



Grades 6-8 SCIENCE

- Solar energy travels in a straight line from the sun and hits different parts of the curved Earth at different angles — more directly at the equator and less directly at the poles.
- The Earth's rotation axis is tilted with respect to its orbital plane around the sun. Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.
- Connections
 - Students use patterns observed from their model to provide causal accounts for events, including:
 - Moon phases:
 - Solar energy coming from the sun bounces off of the moon and is viewed on Earth as the bright part of the moon.
 - The visible proportion of the illuminated part of the moon (as viewed from Earth) changes over the course of a month as the location of the moon relative to Earth and the sun changes.
 - The moon appears to become more fully illuminated until “full” and then less fully illuminated until dark, or “new,” in a pattern of change that corresponds to what proportion of the illuminated part of the moon is visible from Earth.
- Eclipses:
 - Solar energy is prevented from reaching the Earth during a solar eclipse because the moon is located between the sun and Earth.
 - Solar energy is prevented from reaching the moon (and thus reflecting off of the moon to Earth) during a lunar eclipse because Earth is located between the sun and moon.
 - Because the moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun, for a majority of time during an Earth month, the moon is not in a position to block solar energy from reaching Earth, and Earth is not in a position to block solar energy from reaching the moon.
- Students use their model to predict:
 - The phase of the moon when given the relative locations of the Earth, sun, and moon.
 - The relative positions of the Earth, sun, and moon when given a moon phase.
 - Whether an eclipse will occur, given the relative locations of the Earth, sun, and moon and a position on Earth from which the moon or sun can be viewed (depending on the type of eclipse).
 - The relative positions of the Earth, sun, and moon, given a type of eclipse and a position on Earth from which the moon/sun can be viewed.

Stimulus Materials

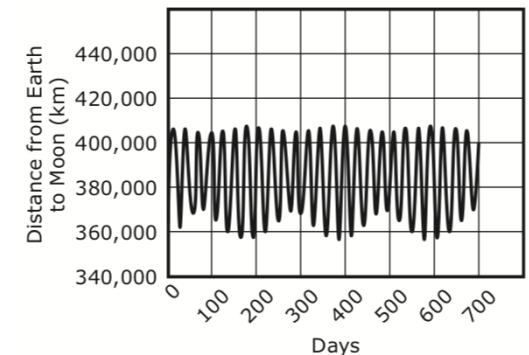
Graphic organizers, diagrams, graphs, data tables, drawings.

The student also discovered Table 1 and Figure 3, which display data of how the distance between the Moon and the Earth changes. Figure 3 was created using data gained through laser-range finding. In this method, lasers on Earth are fired toward reflectors that were left on the Moon by astronauts or probes. The amount of time it takes for each pulse to return to Earth is used to precisely calculate the distance between the Earth and the Moon. Perigee is the point in the Moon's orbit at which it is nearest the Earth. Apogee is the point in the Moon's orbit at which it is farthest from Earth.

Table 1. Distance from Earth to Moon

Position	Distance in kilometers (km)
perigee (point nearest to Earth)	356,565
mean	384,400
apogee (point farthest from the Earth)	406,464

**Figure 3.
Distance from Earth to Moon**



The student modified Figure 1 to make Figure 4 and found Figure 5, which is a representation of images taken by the Lunar

Reconnaissance Orbiter probe, launched in 2009.

Figure 4.
Illumination of the Earth and Moon

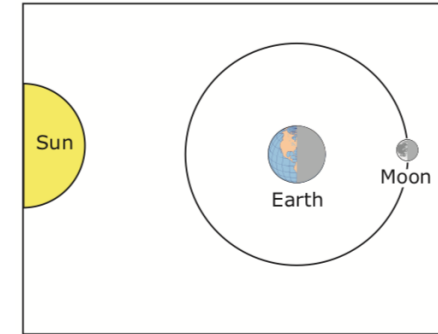
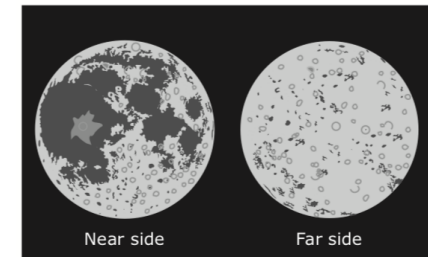


Figure 5.
The Near and Far Sides of the Moon



It takes about 8 minutes and 20 seconds for light from the Sun to reach Earth. Light travels from the Moon to the Earth in about 1.3 seconds. The student found the data in Table 2 about the orbit of the Earth around the Sun. The data from the Sun is based on a technique that involves measuring the movement of the Sun as seen from two locations on Earth that are distant from each other. This method is called triangulation. Compare the data in Table 1 with the data in Table 2 to answer the following questions.

Grades 6-8 SCIENCE

Table 2. Distance Between the Earth and the Sun

Position	Distance (x10 ⁶ km)
perihelion (point nearest to the Sun)	147.1
mean - average	149.6
aphelion (point farthest from the Sun)	152.1

1. Compare the size of the Earth’s orbit around the Sun to the size of the Moon’s orbit around the Earth. Support your comparison with data.
2. What does the pattern of data you see allow you to conclude about the orbits of the Earth and Moon?

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS1.A.2
Core Idea	Earth's Place in the Universe	
Component	The Universe and its Stars	
MLS	Develop and use a model of the Earth-Sun system to explain the cyclical pattern of seasons, which includes Earth's tilt and directional angle of sunlight on different areas of Earth throughout the year.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Examples of models can be physical, graphical, or conceptual.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe the predictability and patterns of seasons on different areas of Earth over the period of a year. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The Universe and Its Stars</p> <ul style="list-style-type: none"> Patterns of the apparent motion of the Sun, moon, and stars in the sky can be observed, described, predicted, and explained with models. <p>Earth and the Solar System</p> <ul style="list-style-type: none"> This model of the solar system can explain eclipses of the sun and the moon. Earth's axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth throughout the year. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Patterns</p> <ul style="list-style-type: none"> Use patterns to identify cause and effect relationships between the relative positions of Earth, the moon, and the Sun and the predictability of seasons on different areas of Earth throughout the period of a year. 		<p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should avoid requiring the memorization of Earth's tilt angle, length of seasons, the angle of the moon's orbital plane relative to Earth, and the orbital period of Earth and the moon.

Possible Evidence

- To make sense of a given phenomenon, students develop a model (physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including
 - Earth, including the tilt of its axis of rotation.
 - the Sun.
 - the moon.
 - solar energy.
- Students indicate the accuracy of size and distance (scale) relationships within the model, including any scale limitations within the model.
- Students use patterns observed from their model to provide causal accounts for events including that
 - because Earth's axis is tilted, the most direct and intense solar energy occurs over the summer months, and the least direct and intense solar energy occurs over the winter months.
 - change in season at a given place on Earth is directly related to the orientation of the tilted earth and the position of Earth in its orbit around the sun because of the change in the directness and intensity of the solar energy at that place over the course of a year.
 - Summer occurs in the Northern Hemisphere at times in Earth's orbit when the northern axis of Earth is tilted toward the Sun. Summer occurs in the Southern Hemisphere at times in Earth's orbit when the southern axis of Earth is tilted toward the Sun.
 - Winter occurs in the Northern Hemisphere at times in Earth's orbit when the northern axis of Earth is tilted away from the Sun. Winter occurs in the Southern Hemisphere at times in Earth's orbit when the southern axis of Earth is tilted away from the Sun.
- Students use the model to predict that
 - the season on Earth, given the relative positions of Earth and the Sun (including the orientation of Earth's axis) and a position on Earth.
 - the relative positions of Earth and the Sun when given a season and a relative position (far north, far south, equatorial) on Earth.

Sample Stems



1. Describe the patterns you see in the data.
2. If the pattern in the data were to continue, predict how the frost will appear on February 14. Use the pattern you see in the data to justify your answer.

Grades 6-8 SCIENCE

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Photo



Figure 1

From the dates on the photo, it is clear Barrow Alaska does not receive much sunlight for many days in the winter.

1.
 - a. Using the location of Barrow, (Figure 1), explain why this happened in 2017?
 - b. Does this happen every year at this same time?
2.
 - a. Does the pattern in the data support the conclusion that is caused by the tilt of the earth?
 - b. Describe your answer to Part A.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS1.A.3
Core Idea	Earth's Place in the Universe	
Component	The Universe and Its Stars	
MLS	Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and the Milky Way galaxy and controls orbital motions within them. Examples of models can be physical or conceptual.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model based on the analysis and interpretation of data to describe the role of gravity in the motions within galaxies and the solar system. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The Universe and Its Star</p> <ul style="list-style-type: none"> Earth and its solar system are part of the Milky Way galaxy, which is one of the many galaxies in the universe. <p>Earth and the Solar System</p> <ul style="list-style-type: none"> The solar system consists of the sun and a collection of objects including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Systems and System Models</p> <ul style="list-style-type: none"> Models can be used to represent systems and their interactions, such as how gravity affects the motions within galaxies and the solar system. <p>Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p> <ul style="list-style-type: none"> Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. 		<p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should avoid Kepler's laws of orbital motion or the apparent retrograde motion of planets as viewed from Earth.
- Tasks should not require students to complete any calculations.

Possible Evidence

- To make sense of a given phenomenon, students develop a model in which they identify the solar system, galaxy, and universe plus their relevant components of the system, including
 - gravity.
 - the solar system as a collection of bodies, including the Sun, planets, moons, and asteroids.
 - the Milky Way galaxy as a collection of stars (e.g., the sun) and their associated systems of objects.
 - other galaxies in the universe.
- Students indicate the relative spatial scales, such as astronomical units and light years, of solar systems and galaxies in the model.
- Students describe the relationships and interactions between components of the solar and galaxy systems, including:
 - gravity as an attractive, non contact force between the solar system and galaxy objects that:
 - increase as the mass of the interacting objects increases.
 - decreases as the distances between objects increase.
 - the orbital motion of objects in our solar system (moons orbit around planets, all objects within the solar system orbit the Sun).
 - the orbital motion, in the form of a disk, of vast numbers of stars around the center of the Milky Way galaxy.
 - that our solar system is one of many systems orbiting the center of the larger system of the Milky Way galaxy.
 - the Milky Way is one of many galaxies in the universe.
- Students use the model to describe that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects.
- Students use the models to describe that gravity causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe, including that
 - gravitational forces from planets cause smaller objects (e.g., moons) to orbit around planets.
 - the gravitational force of the sun causes the planets and other bodies to orbit around it, holding the solar system together.

Sample Stems

	MERCURY	VENUS	EARTH	MOON	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Mass (10 ²⁴ kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0146
Diameter (km)	4879	12,104	12,756	3475	6792	142,984	120,536	51,118	49,528	2370
Gravity (m/s ²)	3.7	8.9	9.8	1.6	3.7	23.1	9.0	8.7	11.0	0.7
Number of Moons	0	0	1	0	2	79	82	27	14	5

1. Using the data provided, determine the relationship between the gravity of the planet and the diameter of the planet.
2. Construct a graph as evidence to support the relationship described.
3. What would happen if the Sun was no longer part of the solar system?

Grades 6-8 SCIENCE

- | | |
|--|--|
| <ul style="list-style-type: none">○ the gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.○ the hierarchy pattern of orbiting systems in the solar system was established early in its history as the disk of dust and gas was driven by gravitational forces to form moon-planet and planet-sun orbiting systems.● Students use the model to describe that objects too far away from the sun do not orbit it because the sun's gravitational force on those objects is too weak to pull them into orbit.● Students use the model to describe what a given phenomenon might look like without gravity (e.g., smaller planets would move in straight paths through space rather than orbiting a more massive body). | |
| <p style="text-align: center;"><u>Stimulus Materials</u></p> <p>Graphic organizers, diagrams, graphs, data tables, drawings</p> | |

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS1.B.1
Core Idea	Earth's Place in the Universe	
Component	Earth and the Solar System	
MLS	Analyze and interpret data to determine scale properties of objects in the solar system.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to determine similarities and differences in findings to determine the relationship between scale, proportion, and quantity and their effects on certain properties. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Earth and the Solar System</p> <ul style="list-style-type: none"> The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small to be directly observed. The solar system is a large system that must be reduced in order to study it in a classroom setting. <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. 		<p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should not require students to recall facts about properties of planets and other bodies in the solar system.
- Tasks should not require students to have memorized formulas or scale values (e.g., astronomical units).

Possible Evidence

- Students organize given data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth- and space-based instruments to allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).
- Students describe that different representations illustrate different characteristics of objects in the solar system, including differences in scale.
- Students use quantitative analyses to describe similarities and differences of solar system objects by describing patterns of features of those objects at different scales including
 - distance from the sun.
 - diameter.
 - surface features (e.g., sizes of volcanoes).
 - structure.
 - composition.
- Students identify advances in solar system science made possible by improving engineering (e.g., knowledge of the evolution of the solar system from lunar exploration and space probes) and new developments in engineering made possible by advances in science (e.g., space-based telescopes from advances in optics and aerospace engineering).
- Students use the patterns they find in multiple types of data at varying scales to draw conclusions about the identifying characteristics of different categories of solar system objects (e.g., planets, meteors, asteroids, comets) based on their features, composition, and locations within the solar system (e.g., most asteroids are rocky bodies between Mars and Jupiter, while most comets reside in orbits farther from the sun and are composed mostly of ice).
- Students use patterns in data as evidence to describe that two objects may be similar when viewed at one scale (e.g., types of surface features) but may appear to be quite different when viewed at a different scale (e.g., diameter or number of natural satellites).

Sample Stems

	MERCURY	VENUS	EARTH	MOON	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Mass (10 ²⁴ kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0146
Diameter (km)	4879	12,104	12,756	3475	6792	142,984	120,536	51,118	49,528	2370
Gravity (m/s ²)	3.7	8.9	9.8	1.6	3.7	23.1	9.0	8.7	11.0	0.7
Number of Moons	0	0	1	0	2	79	82	27	14	5

- Using the data from the table, determine if there is a relationship between the mass of a planet and its diameter.



- Take a look at the picture of the night sky above. When looking at the night sky without a telescope, why does the moon appear so much larger than Jupiter?
 - the moon is larger in size than Jupiter
 - the moon is brighter than Jupiter
 - Jupiter is further away than the moon**
 - Jupiter has many moons that block its light

Grades 6-8 SCIENCE

- Students use the organization of data to facilitate drawing conclusions about the patterns of scale properties at more than one scale, such as those that are too large or too small to directly observe.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings



Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS1.C.1
Core Idea	Earth's Place in the Universe	
Component	The History of Planet Earth	
MLS	Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's history.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last ice age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Explain how evidence from rock strata is a reliable source to construct a time scale of Earth's history. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The History of Planet Earth</p> <ul style="list-style-type: none"> The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Scale, Proportion, and Quantity</p> <ul style="list-style-type: none"> Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small to be observed directly. The geologic time scale is for relative dating purposes; it is not an absolute scale. 		<u>Item Format</u> Selected Response Constructed Response Technology Enhanced

Grades 6-8 SCIENCE

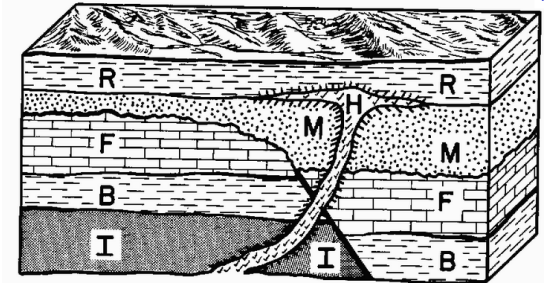
Content Limits/Assessment Boundaries

- Tasks should not require students to recall the names of geologic time periods or the events that occurred within those time periods.
- Tasks should not require students to name or identify fossils.

Possible Evidence

- Students articulate a statement that relates the given phenomenon to a scientific idea, including how events in Earth's 4.6 billion-year-old history are organized relative to one another using the geologic time scale.
- Students use evidence and reasoning to construct an explanation. In their explanation, students describe how the relative order of events is determined on the geologic time scale using
 - rock strata and relative ages of rock units (e.g., patterns of layering).
 - major events in Earth's history and/or specific changes in fossils over time (e.g., formation of mountain chains, formation of ocean basins, volcanic eruptions, glaciations, asteroid impacts, extinctions of groups of organisms).
- Students identify and describe the evidence necessary for constructing the explanation, including
 - types and order of rock strata.
 - the fossil record.
 - identification of and evidence for major event(s) in the Earth's history for example volcanic eruptions and asteroid impacts.
- Students use multiple valid and reliable sources of evidence that may include students' own experiments.
- Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support the explanations for how the geologic time scale is used to construct a timeline of Earth's history. Students describe the following chain of reasoning for their explanation:
 - Unless they have been disturbed by subsequent activity, newer rock layers sit on top of older rock layers, allowing for a relative ordering in time of the formation of the layers (i.e., older sedimentary rocks lie beneath younger sedimentary rocks).
 - Any rocks or features that cut existing rock strata are younger than the rock strata that they cut (a younger fault cutting across older, existing rock strata).
 - The fossil record can provide relative dates based on the appearance or disappearance of organisms (e.g., fossil layers that contain only extinct animal groups are usually older than fossil layers that

Sample Stems



1. Order the rock layers from oldest to youngest.
2. Mark at which time the unconformity (crack) in the layers formed.
3. Provide a possible explanation for the unconformity

Grades 6-8 SCIENCE

<p>contain animal groups that are still alive today; layers with only microbial fossils are typical of the earliest evidence of life).</p> <ul style="list-style-type: none">○ Specific major events (e.g., extensive lava flows, volcanic eruptions, asteroid impacts) can be used to indicate periods of time that occurred before a given event from periods that occurred after it.○ Using a combination of the order of rock layers, the fossil record, and evidence of major geologic events, the relative time ordering of events can be constructed as a model for Earth’s history, even though the timescales involved are immensely vaster than the lifetimes of humans or the entire history of humanity.	
<p><u>Stimulus Materials</u></p> <p>Graphic organizers, diagrams, graphs, data tables, drawings</p>	

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.A.1
Core Idea	Earth's Systems	
Component	Earth Materials and Systems	
MLS	Develop and use a model to illustrate that energy from Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering, and deformation of large rock formations, including generation of ocean seafloor at ridges, submergence of ocean seafloor at trenches, mountain building and active volcanic chains.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics that includes changes in rock types through erosion, heat, and pressure.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe its relationship between energy from Earth's interior and the continuous construction of Earth's crust and the formation of ridges, trenches, mountains, and active volcanic chains. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Earth's Materials and Systems</p> <ul style="list-style-type: none"> All Earth processes are the result of energy flowing and matter cycling within and between the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and the matter that cycles produce chemical and physical changes in Earth's materials and living organisms. <p><u>CROSCUTTING CONCEPTS</u></p> <p>Stability and Change</p> <ul style="list-style-type: none"> Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales including the atomic scale. Use stability and change to describe the relationship between energy from Earth's interior and the continuous construction of Earth's crust and the formation of ridges, trenches, mountains, and active volcanic chains. 		<u>Item Format</u> Selected Response Constructed Response Technology Enhanced

Grades 6-8 SCIENCE

<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> • Tasks should not include identifying rocks and minerals. • Tasks should not require rote memorization of the rock cycle, Earth's layers, or tectonic plate names. • Tasks should not require students to calculate how far a tectonic plate has moved in a given time span. 	<p align="center"><u>Sample Stems</u></p>
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> • To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including <ul style="list-style-type: none"> ○ general types of Earth materials that can be found in different locations, including <ul style="list-style-type: none"> ▪ those located at the surface exterior or in the interior. ▪ those that existed) before and after chemical and physical changes that occur during Earth processes (e.g., melting, sedimentation, weathering). ○ energy from the sun. ○ energy from the Earth's hot interior. ○ relevant earth processes. ○ the temporal and spatial scales for the system. • In the model, students describe the relationships between components, including <ul style="list-style-type: none"> ○ different Earth processes (e.g., melting, sedimentation, crystallization) drive matter to cycle through observable chemical and physical changes. ○ the movement of energy that originates from Earth's hot interior and causes the cycling of matter through Earth processes of melting, crystallization, and deformation. ○ energy flows from the Sun cause matter to cycle via processes that produce weathering, erosion, and sedimentation (e.g., wind, rain). ○ the temporal and spatial scales over which relevant Earth processes operate. • Students use the model to describe (based on evidence for changes over time and processes at different scales) that energy from Earth's interior and the sun drive Earth processes that together cause matter to cycle through different forms of Earth materials. • Students use the model to account for interactions between different Earth processes, including that <ul style="list-style-type: none"> ○ Earth's internal heat energy drives processes such as melting, crystallization, and deformation that change the atomic arrangement of elements in rocks and that move and push rock material to Earth's surface where it is subject to surface processes like weathering and erosion. 	<div data-bbox="1465 250 1955 578" data-label="Image"> </div> <p>A student stated that water heating on the stove is a model of the movement of energy that originates from Earth's hot interior.</p> <ol style="list-style-type: none"> 1. Explain how the model mimics the movement of energy inside the earth and where the model is lacking (what improvements can be made to the model). 2. What things change in the system? <p>The movement of energy causes the cycling of matter through Earth processes (melting, crystallization, and deformation).</p> <ol style="list-style-type: none"> 3. a. Could the student use the same model to explain this statement? b. Explain your answer to part A.

Grades 6-8 SCIENCE

- energy from the Sun drives the movement of wind and water that causes the erosion, movement, and sedimentation of weathered Earth material.
- given the right setting, any rock on Earth can be changed into a new type of rock by processes driven by Earth's internal energy or by energy from the Sun.
- Students describe that these changes are consistently occurring but that landforms appear stable to humans because they are changing on time scales much longer than human lifetimes.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.A.2
Core Idea	Earth's Systems	
Component	Earth Materials and Systems	
MLS	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future. Construct an explanation that describes how geoscience processes have occurred rapidly, gradually, or over large spans of time and over small to large spatial scale. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Earth's Materials and Systems</p> <ul style="list-style-type: none"> The planets interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. <p>The Roles of Water in Earth's Surface Processes</p> <ul style="list-style-type: none"> Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. 		<p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

CROSCUTTING CONCEPTS

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small to be directly observed.
- On both large and small spatial scales, gather evidence of geoscience processes to construct an explanation.

Content Limits/Assessment Boundaries

- Tasks should focus on relative time scales.
- Tasks should not require the memorization of facts, observations, or data that can be used as evidence.

Possible Evidence

- Students articulate a statement that relates a given phenomenon to a scientific idea, including that geoscience processes have changed Earth's surface at varying time and spatial scales.
- Students use evidence and reasoning to construct an explanation for the given phenomenon, which involves changes at Earth's surface.
- Students identify and describe the evidence necessary for constructing an explanation, including
 - the slow- and large-scale motion of Earth's plates and the results of those motions.
 - surface weathering, erosion, movement, and the deposition of sediment ranging from large to microscopic scale (e.g., sediment consisting of boulders and microscopic grains of sand, raindrops dissolving microscopic amounts of minerals).
 - rapid catastrophic events.
- Students identify the corresponding time scales for each identified geoscience process.
- Students use multiple valid and reliable sources, which may include students' own investigations, evidence from data, and observations from conceptual models used to represent changes that occur on very large or small spatial and/or temporal scales (e.g., stream tables to illustrate erosion and deposition, maps and models to show the motion of tectonic plates).
- Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for how geoscience processes have changed Earth's surface at a variety of temporal and spatial scales. Students describe the following chain of reasoning for their explanation:

Sample Stems

The first image of the Northern Chandeleur Islands located in the Gulf of Mexico was taken in July 2001.

Image 1



The second image was taken at the same site on August 31, 2005.

Image 2



Grades 6-8 SCIENCE

- The motion of Earth's plates produces changes on a planetary scale over a range of time periods from millions to billions of years. Evidence for the motions of plates can explain large-scale features of Earth's surface (e.g., mountains, distribution of continents) and how they change.
- Surface processes such as erosion, movement, weathering, and deposition of sediment can modify surface features, such as mountains, or create new features, such as canyons. These processes can occur at spatial scales ranging from large to microscopic over time periods ranging from years to hundreds of millions of years.
- Catastrophic changes can modify or create surface features over a very short period of time compared to other geoscience processes, and the results of those catastrophic changes are subject to further changes over time by processes that act on longer time scales (e.g., erosion of a meteor crater).
- A given surface feature is the result of a broad range of geoscience processes occurring at different temporal and spatial scales.
- Surface features will continue to change in the future as geoscience processes continue to occur.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

1. Make a claim and support it with a piece of evidence from the photos to explain what happened during the four year time span.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.B.1
Core Idea	Earth's Systems	
Component	Plate Tectonics and Large-Scale Systems	
MLS	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data to provide evidence for and explain plate tectonic movement over time and at various scales. <p>Scientific Knowledge is Open to Revision in Light of New Evidence</p> <ul style="list-style-type: none"> Science findings are frequently revised and/or reinterpreted based on new evidence. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The History of Planet Earth</p> <ul style="list-style-type: none"> Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. <p>Plate Tectonics and Large-Scale System Interactions</p> <ul style="list-style-type: none"> Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. <p><u>CROSSCUTTING CONCEPTS:</u></p> <p>Patterns</p> <ul style="list-style-type: none"> Patterns are determined from the analysis and interpretation of data to use as evidence for explanations. The explanation may be revised when new data or interpretation is presented. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <hr/> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should avoid paleomagnetic anomalies in oceanic or continental crust.
- Tasks should not require the memorization of names or locations of tectonic plates, names of fossils, or the names and locations of ridges, fracture zones, and trenches.

Possible Evidence

- Students organize given data that represent the distribution and ages of fossils and rocks, continental shapes, seafloor structures, and/or age of oceanic crust.
- Students describe what each dataset represents.
- Students organize the given data in a way that facilitates analysis and interpretation.
- Students analyze the data to identify relationships (including relationships that can be used to infer numerical rates of change, such as patterns of age of seafloor) in the datasets about Earth features.
- Students use the analyzed data to provide evidence for past plate motion. Students describe the following patterns:
 - Regions of different continents that share similar fossils and similar rocks suggest that, in the geologic past, those sections of continents were once attached and have since separated.
 - The shapes of continents, which roughly fit together (like pieces in a jigsaw puzzle) suggest that those land masses were once joined and have since separated.
 - The separation of continents by the sequential formation of new seafloor at the center of the ocean is inferred by age patterns in oceanic crust that increase in age from the center of the ocean to the edges of the ocean.
 - The distribution of seafloor structures (e.g., volcanic ridges at the centers of oceans, trenches at the edges of continents) combined with the patterns of ages of rocks of the seafloor (youngest ages at the ridge, oldest ages at the trenches) supports the interpretation that new crust forms at the ridges and then moves away from the ridges as new crust continues to form and that the oldest crust is being destroyed at seafloor trenches.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Sample Stems

[Download Nannofossils Reveal Seafloor Spreading Truth](#)

Table 1

Site Number	Paleontological Age of Sediment (m.y.)	Distance From Ridge Axis (km)
16	11	221
15	24	422
18	26	506
17	33	718
14	40	745
19	49	1010
20	67	1303
21	76	1686

Adapted from Table S, from Initial Reports of DSDP, Volume 3

Figure 1

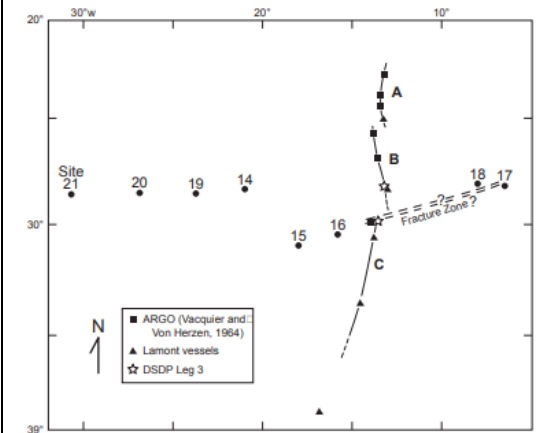


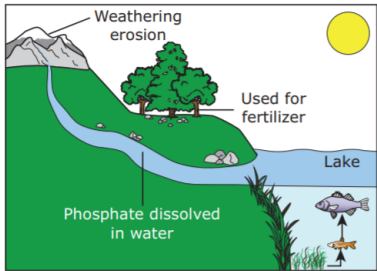
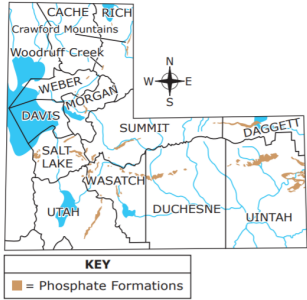
Figure 2. Location of DSDP Leg 3 drillsites relative to the axis of the Mid-Atlantic Ridge in the South Atlantic. Lines of latitude are in degrees South (i.e., 20° to 39°S)

1. Does the pattern in the data support the conclusion that fossils are related to seafloor spreading? Why or why not?
2. Provide an explanation for how the data and model provide evidence of seafloor spreading.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.C.1
Core Idea	Earth's Systems	
Component	The Role of Water in Earth's Surface Processes	
MLS	Design and develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u>
[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.]		3
<u>SCIENCE AND ENGINEERING PRACTICES</u>		<u>Item Format</u>
Developing and Using Models		Selected Response
<ul style="list-style-type: none"> Develop a model to describe unobservable mechanisms. Design and develop a model to describe the absorption or release of energy as water changes its state and moves through the hydrologic cycle. 		Constructed Response
<u>DISCIPLINARY CORE IDEAS</u>		Technology Enhanced
The Roles of Water in Earth's Surface Processes		
<ul style="list-style-type: none"> Water continually cycles between land, ocean, and atmosphere via transpiration, evaporation, condensation, crystallization, and precipitation, as well as downhill flows on land. <ul style="list-style-type: none"> Global movements of water and its changes in form are propelled by sunlight and gravity. 		
<u>CROSSCUTTING CONCEPTS</u>		
Energy and Matter		
<ul style="list-style-type: none"> Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. <ul style="list-style-type: none"> Design and develop a model to describe the absorption or release of energy as water changes its state and moves through the hydrologic cycle. 		

Grades 6-8 SCIENCE

<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> • Tasks should avoid a quantitative understanding of latent heats of vaporization and fusion. • Tasks should not require any calculations. 	<p align="center"><u>Sample Stems</u></p> <p>A student finds a rock and shows it to his teacher, who says it contains phosphate. The teacher explains that rocks containing phosphate are mined and broken down for use in fertilizers. The student conducts research to find out more about phosphate in the area where he lives. Phosphate is an essential mineral for living things.</p>
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> • To make sense of a phenomenon, students develop a model (conceptual or physical) in which they identify the relevant components: <ul style="list-style-type: none"> ○ water (liquid, solid, and in the atmosphere) ○ energy in the form of sunlight ○ gravity ○ atmosphere ○ landforms ○ plants and other living things ○ In their model, students describe the relevant relationships between components, including: <ul style="list-style-type: none"> ○ energy transfer from the sun warms water on Earth, which can evaporate into the atmosphere. ○ water vapor in the atmosphere forms clouds, which can cool and condense to produce precipitation that falls to the surface of Earth. ○ gravity causes water on land to move downhill (e.g., rivers and glaciers) and much of it eventually flows into oceans. ○ some liquid and solid water remains on land in the form of bodies of water and ice sheets. ○ some water remains in the tissues of plants and other living organisms, and this water is released when the tissues decompose. • Students use the model to account for both energy from light and the force of gravity driving water cycling between oceans, the atmosphere, and land, including that <ul style="list-style-type: none"> ○ energy from the sun drives the movement of water from Earth (e.g., oceans, landforms, plants) into the atmosphere through transpiration and evaporation. ○ water vapor in the atmosphere can cool and condense to form rain or crystallize to form snow or ice, which returns to Earth when pulled down by gravity. ○ some rain falls back into the ocean and some rain falls on land. Water that falls on land can <ul style="list-style-type: none"> ■ be pulled down by gravity to form surface waters such as rivers, which join together and generally flow back into the ocean. ■ evaporate back into the atmosphere. 	<p align="center"><u>Figure 1: Phosphate in Environment</u></p>  <p align="center"><u>Figure 2: Phosphate Deposits in Utah Counties</u></p> 

Grades 6-8 SCIENCE

- be taken up by plants, which release it through transpiration and also eventually through decomposition.
- be taken up by animals, which release it through respiration and also eventually through decomposition.
- freeze (crystallize) and/or collect in frozen form, in some cases forming glaciers or ice sheets.
- be stored on land in bodies of water or below ground in aquifers.
- Students use the model to describe that the transfer of energy between water and its environment drives the phase changes that drive water cycling through evaporation, transpiration, condensation, crystallization, and precipitation.
- Students use the model to describe how gravity interacts with water in different phases and locations to drive water cycling between Earth's surface and the atmosphere.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Table 1: Probability of Phosphate by Rock Type in Each County

County	Igneous Rock	Sedimentary Rock
Cache	Low	Low
Daggett	Low	High
Duchesne	Low	Medium
Morgan	Low	Low
Rich	Low	Medium
Salt Lake	Low	High
Summit	Low	Low
Uintah	Low	High
Utah	Low	Low
Wasatch	Low	High
Weber	Low	Medium

1. Which of these causes the water in the river to cycle through the area in Figure 1? Select **three** correct answers.
 - a. rocks
 - b. the Sun**
 - c. gravity**
 - d. the plants**
 - e. phosphate
2. The student wants to make a model to show how phosphate cycles in this area. Put the descriptions of the parts of the model, beginning with the first step, in the correct order.

Step 1: Water in the lake is heated by the sun, evaporating and leaving phosphate minerals behind.

Step 2:

Step 3:

Step 4:

Step 5:

Answer Choices:

Grades 6-8 SCIENCE

	<ul style="list-style-type: none">a) Clouds become heavy and precipitation falls.b) Water vapor condenses in the atmosphere forming clouds.c) Water collects into larger stream that flow into the river and into the lake.d) Precipitation falls, weathering rocks and carrying rock sediment as it flows downhill. <p>3. Water on the map is affected by the non-living environment. Match each description to the cause (gravity, the Sun, or both) that is involved.</p> <ul style="list-style-type: none">a) Phosphate in the mountain is weathered and eroded.b) The river deposits dissolved phosphate in the lake.c) The trees release water from their leaves into the atmosphere.d) Water evaporates and condenses to form clouds.e) Snow falls at high altitudes in the mountains.
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Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.C.2
Core Idea	Earth's Systems	
Component	The Role of Water in Earth's Surface Processes	
MLS	Research, collect, and analyze data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Planning and Carrying Out Investigations</p> <ul style="list-style-type: none"> Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. Research, collect, and analyze data to provide evidence for cause and effect relationships between air masses and changing weather conditions. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The Roles of Water in Earth's Surface Processes</p> <ul style="list-style-type: none"> The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents are major determinants of local weather patterns <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships may be used to predict phenomena in natural or designed systems. Cause and effect relationships show the relationship between air masses and changing weather conditions. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should not require students to recall the names of cloud types or weather symbols. 	<p align="center"><u>Sample Stems</u></p>
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> From the given investigation plan, students describe the phenomenon under investigation, which includes the relationships between air mass interactions and weather conditions. Students identify the purpose of the investigation, which includes providing evidence to answer questions about how motions and complex interactions of air masses result in changes in weather conditions (note: expectations of students regarding mechanisms are limited to relationships between patterns of activity of air masses and changes in weather). From a given investigation plan, students describe the data to be collected and the evidence to be derived from the data that would indicate relationships between air mass movement and changes in weather, including <ul style="list-style-type: none"> patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time. the relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents. the relationship between observed, large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms). Students describe how the evidence to be collected will be relevant to determining the relationships between patterns of activity of air masses and changes in weather conditions. Students describe that because weather patterns are so complex and have multiple causes, weather can be predicted only probabilistically. Students describe the tools and methods used in the investigation, including how they are relevant to the purpose of the investigation. According to the provided investigation plan, students make observations and record data, either firsthand and/or from professional weather monitor services. 	<div data-bbox="1438 224 1955 565"> </div> <ol style="list-style-type: none"> What properties of the air masses determine the current weather conditions in the southwest? Use the diagram to describe how the air masses will move and what weather conditions will be in Missouri.
<p align="center"><u>Stimulus Materials</u></p> <p>Graphic organizers, diagrams, graphs, data tables, drawings</p>	

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS2.C.3
Core Idea	Earth's Systems	
Component	The Role of Water in Earth's Surface Processes	
MLS	Develop and use a model to describe how unequal heating and rotation of Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop and use a model to describe the interaction of uneven heating and the rotation of Earth to produce systems of oceanic and atmospheric currents that determine regional climates. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>The Roles of Water in Earth's Surface Processes</p> <ul style="list-style-type: none"> Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. <p>Weather and Climate</p> <ul style="list-style-type: none"> Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>System and System Models</p> <ul style="list-style-type: none"> Models are based on systems. The model describes the interaction of uneven heating and the rotation of Earth to produce systems of oceanic and atmospheric currents that determine regional climates. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should avoid the dynamics of the Coriolis effect.

Possible Evidence

- To make sense of a phenomenon, students develop a model in which they identify the relevant components of the system, with inputs and outputs, including
 - the rotating Earth, the atmosphere, the ocean (including the relative rate of thermal energy transfer of water compared to land or air), the continents and the distribution of landforms on the surface of Earth, global distribution of ice, distribution of living things,
 - energy, including
 - radiation from the sun as an input.
 - thermal energy that exists in the atmosphere, water, land, and ice (as represented by temperature).
- In the model, students identify and describe the relationships between components of the system, including
 - Differences in the distribution of solar energy and temperature changes
 - Higher latitudes receive less solar energy per unit of area than do lower latitudes, resulting in temperature differences based on latitude.
 - Smaller temperature changes tend to occur in oceans than on land in the same amount of time.
 - In general, areas at higher elevations have lower average temperatures than do areas at lower elevations.
 - Features on the Earth's surface, such as the amount of solar energy reflected back into the atmosphere or the absorption of solar energy by living things, affect the amount of solar energy transferred into heat energy.
 - Motion of ocean waters and air masses (matter)
 - Fluid matter (i.e., air and water) flows from areas of higher density to areas of lower density (due to temperature or salinity). The density of a fluid can vary for several different reasons (e.g., changes in salinity and temperature of water can each cause changes in density). Differences in salinity and temperature can, therefore, cause fluids to move vertically and, as a result of vertical movement, also horizontally because of density differences.
 - Factors affecting the motion of wind and currents

Sample Stems

Figure 1 -



Figure 2 -



Table 1 - Average High Temperatures

City	June	July	August
Salt Lake City, UT	82	90	88
Naples, Italy	70	77	77

1. Describe how conditions of two cities on the same latitude are different and cause the average high temperatures to vary.

Grades 6-8 SCIENCE

- Earth's rotation causes oceanic and atmospheric flows to curve when viewed from the rotating surface of Earth (Coriolis effect).
- The geographical distribution of land limits where ocean currents can flow.
- Landforms affect atmospheric flows (e.g., mountains deflect wind and/or force it to higher elevation).
- Thermal energy transfer
 - Thermal energy moves from areas of high temperature to areas of lower temperature either through the movement of matter, via radiation, or via conduction of heat from warmer objects to cooler objects.
 - Absorbing or releasing thermal energy produces a more rapid change in temperature on land compared to in water.
 - Absorbing or releasing thermal energy produces a more rapid change in temperature in the atmosphere compared to either on land or in water, so the atmosphere is warmed or cooled by being in contact with land or the ocean.
- Students use the model to describe the following:
 - The general latitudinal pattern in climate (higher average annual temperatures near the equator and lower average annual temperatures at higher latitudes) is caused by more direct light (greater energy per unit of area) at the equator (more solar energy) and less direct light at the poles (less solar energy)
 - The general latitudinal pattern of drier and wetter climates is caused by the shift in the amount of air moisture during precipitation from rising moisture-rich air and the sinking of dry air.
 - The pattern of differing climates in continental areas as compared to the oceans occurs because water can absorb more solar energy for every degree change in temperature compared to land, so there is a greater and more rapid temperature change on land than in the ocean. At the centers of landmasses, this leads to conditions typical of continental climate patterns.
 - The pattern that climates near large water bodies, such as marine coasts, have comparatively smaller changes in temperature relative to center of the landmass occurs because land near the oceans can exchange thermal energy through the air, resulting in smaller changes in temperature. At the edges of landmasses, this leads to marine climates.
 - The pattern that climates at higher altitudes have lower temperatures than climates at lower altitudes occurs because of the direct relationship between temperature and pressure. Given the same amount of thermal energy, air at lower pressures (higher altitudes) will have lower temperatures than air at higher pressures (lower altitudes).
 - Regional patterns of climate (e.g., temperature or moisture) are related to a specific patterns of water or air circulations, including the role of the following in contributing to the climate pattern:

Grades 6-8 SCIENCE

- Air or water moving from areas of high temperature, density, and/or salinity to areas of low temperature, density, and/or salinity
- Earth’s rotation, which affects atmospheric and oceanic circulation
- The transfer of thermal energy with the movement of matter
- The presence of landforms (e.g., the rain shadow effect)
- Students use the model to describe the role of each of its components in producing a given regional climate

Stimulus Materials

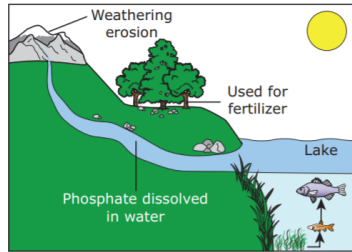
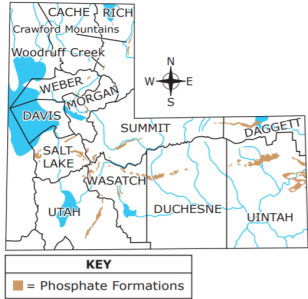
Graphic organizers, diagrams, graphs, data tables, drawings



Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS3.A.1
Core Idea	Earth and Human Activity	
Component	Natural Resources	
MLS	Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes and human activity.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Construct a scientific explanation based on evidence that demonstrates how human activity and geoscience process, both past current, cause uneven distribution of Earth’s resources. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Human Impacts on Earth Systems</p> <ul style="list-style-type: none"> Typically, as human populations and per-capita consumption of natural resources increases, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Influence of Science, Engineering, and Technology on Society and the Natural world</p> <ul style="list-style-type: none"> All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. 		<u>Item Format</u> Selected Response Constructed Response Technology Enhanced

Grades 6-8 SCIENCE

<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should provide students with all needed evidence. 	<p align="center"><u>Sample Stems</u></p> <p>A student finds a rock and shows it to his teacher, who says it contains phosphate. The teacher explains that rocks containing phosphate are mined and broken down for use in fertilizers. The student conducts research to find out more about phosphate in the area where he lives. Phosphate is an essential mineral for living things.</p>
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> Students articulate a statement relating a given phenomenon to scientific ideas, including that past and current geoscience processes have caused the uneven distribution of Earth's resources, including that <ul style="list-style-type: none"> the uneven distributions of Earth's mineral, energy, and groundwater resources are the results of past and current geologic processes. resources are typically limited and nonrenewable due to factors such as the long amounts of time required for some resources to form or the environment in which resources were created once or only rarely in Earth's history. Students use evidence and reasoning to construct a scientific explanation of the phenomenon. Students identify and describe the evidence necessary for constructing the explanation, including <ul style="list-style-type: none"> type and distribution of an example of each type of Earth resources: mineral, energy, and groundwater. evidence for the past and current geologic processes (e.g., volcanic activity, sedimentary processes) that have resulted in the formation of each of the given resources. the ways in which the extraction of each type of resource by humans changes how much and where more of that resource can be found. Students use reasoning to connect the evidence and support an explanation. Students describe a chain of reasoning that includes the following: <ul style="list-style-type: none"> Earth's resources are formed as a result of past and current geologic processes. The environment or conditions that formed the resources are specific to certain areas and/or times on Earth, thus identifying why those resources are found only in those specific places/periods. As resources are used, they are depleted from the sources until they can be replenished, mainly through geologic processes. Because many resources continue to be formed in the same ways that they were in the past and because the amount of time required to form most of these resources (e.g., minerals, fossil fuels) is much longer than the timescales of human lifetimes, these resources are limited to current and near-future generations. Some resources (e.g., groundwater) can be replenished in human timescales and are limited based on distribution 	<p align="center"><u>Figure 1: Phosphate in Environment</u></p>  <p align="center"><u>Figure 2: Phosphate Deposits in Utah Counties</u></p> 

Grades 6-8 SCIENCE

- The extraction and use of resources by humans decreases the amounts of these resources available in some locations and changes the overall distribution of these resources on Earth.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Table 1: Probability of Phosphate by Rock Type in Each County

County	Igneous Rock	Sedimentary Rock
Cache	Low	Low
Daggett	Low	High
Duchesne	Low	Medium
Morgan	Low	Low
Rich	Low	Medium
Salt Lake	Low	High
Summit	Low	Low
Uintah	Low	High
Utah	Low	Low
Wasatch	Low	High
Weber	Low	Medium

A mining company is considering mining the phosphate from this mountain in Figure 1.

1. Describe a consequence of mining phosphorus from the mountain.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS3.B.1
Core Idea	Earth and Human Activity	
Component	Natural Hazards	
MLS	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze and interpret data on natural hazards to identify and analyze patterns for the purpose of predicting future events and developing technologies do minimize their effects. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Natural Hazards</p> <ul style="list-style-type: none"> Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Patterns</p> <ul style="list-style-type: none"> Graphs, charts, and images can be used to identify patterns in data. <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>
<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should provide students will all needed evidence. 		<u>Sample Stem</u>

Grades 6-8 SCIENCE

Possible Evidence

- Students organize given data that represent the type of natural hazard event and features associated with that type of event, including the location, magnitude, frequency, and any associated precursor event or geologic forces.
- Students organize data in a way that facilitates analysis and interpretation.
- Students describe what each dataset represents.
- Students analyze data to identify and describe patterns in the datasets, including the
 - the location of natural hazard events relative to geographic and/or geologic features.
 - frequency of natural hazard events.
 - severity of natural hazard events.
 - types of damage caused by natural hazard events.
 - location or timing of features and phenomena (e.g., aftershocks, flash floods) associated with natural hazard events.
- Students describe similarities and differences between identified patterns.
- Students use the analyzed data to describe
 - areas that are susceptible to the natural hazard events, including areas designated as at the greatest and least risk for severe events.
 - how frequently areas, including areas experiencing the highest and lowest frequency of events are at risk.
 - what type of damage each area is at risk for during a given natural hazard event.
 - what features, if any, occur before a given natural hazard event and can be used to predict the occurrence of the natural hazard event and when and where they can be observed.
- Using patterns in the data, students make a forecast for the potential of a natural hazard event to affect an area in the future, including information on frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event.
- Students give at least three examples of the technologies that engineers have developed to mitigate the effects of natural hazards (e.g., the design of buildings and bridges to resist earthquakes, warning sirens for tsunamis, storm shelters for tornadoes, levees along rivers to prevent flooding).

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Magnitude	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
8.0-9.9	1	1	0	1	2	1	1	4	0	1	1
7.0-7.9	14	15	13	14	14	10	10	14	12	16	22
6.0-6.9	168	126	130	140	145	140	142	112	166	146	130
5.0-5.9	1,095	1,081	1,118	1,081	1,015	1,003	1,112	1,085	1,037	1,056	1,081
4.0-4.9	8,045	8,084	8,084	8,462	10,888	13,917	12,818	11,215	11,943	8,805	10,363
3.0-3.9	4,784	6,151	5,805	7,824	11,832	9,781	9,990	9,816	11,138	2,885	4,321
2.0-2.9	5,108	6,162	5,415	7,227	6,316	6,536	6,287	5,953	5,942	3,014	4,202
1.0-1.9	1,026	944	1,137	2,006	1,344	26	18	41	75	26	39
0.1-0.9	5	1	10	136	103	0	2	2	0	1	10
Without magnitude		5,120	2,038	2,037	6,888	2,039	864	628	1,825	17	24
Total	22,216	23,534	21,814	31,415	31,194	30,418	25,168	25,811	30,193	14,821	21,046
Number of deaths	231	21,267	1,085	30,899	28,619	82,364	6,405	712	88,011	6,786	128,128

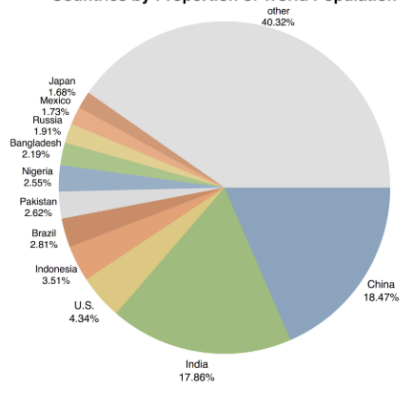
Source: National Earthquake Information Center, U.S. Geological Survey. Web: neic.usgs.gov/neis/eqlists/eqstats.html

- What patterns do you observe in the data presented above in the table?
- Using the data in the table, determine if earthquakes can be predicted.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS3.C.1
Core Idea	Earth and Human Activity	
Component	Human Impacts on Earth's Systems	
MLS	Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's Systems.	
<p align="center"><u>Expectation Unwrapped</u></p> <p>[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Examine the environmental impact of human water and land usage and pollution to design a method for monitoring and minimizing those impacts. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Human Impacts on Earth's Systems</p> <ul style="list-style-type: none"> Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships may be used to predict phenomena in natural or designed systems <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. <p>Science Addresses Questions About the Natural and Material World</p> <ul style="list-style-type: none"> Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <hr/> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

<p style="text-align: center;"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should be limited to given data sets (e.g., human population, per capita consumption of natural resources) 	<p style="text-align: center;"><u>Sample Stems</u></p>
<p style="text-align: center;"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> Students make a claim, to be supported by evidence, to support or refute an explanation or model for a given phenomenon. Students include the following idea in their claim: that increases in the size of the human population and per-capita consumption of natural resources affect Earth systems. Students identify evidence to support the claim from the given materials, including <ul style="list-style-type: none"> changes in the size of human population(s) in a given region or ecosystem over a given timespan. per-capita consumption of resources by human in a given region or ecosystem over a given timespan. changes in Earth systems in a given region or ecosystem over a given timespan. the ways engineered solutions have altered the effects of human activities on Earth's system. (ETS1.A.1) Students use reasoning to connect the evidence and evaluation to the claim. In their arguments, students describe a chain of reasoning that <ul style="list-style-type: none"> increases in the size of the human population or in the per-capita consumption of a given population causes increases in the consumption of natural resources. natural resource consumption causes changes in Earth systems. because human population growth affects natural resource consumption and natural resource consumption has an effect on Earth systems, changes in human populations have a causal role in changing Earth systems. engineered solutions alter the effects of human population on Earth systems by changing the rate of natural resource consumption or mitigating the effects of changes in Earth systems. (ETS1.A.1) 	<p style="text-align: center;">Countries by Proportion of World Population</p>  <p>1. a. Based on population, which country(ies) produce the most carbon dioxide? Use evidence from the model to support your answer. b. What additional information is needed to determine if your claim in Part A is supported or not?</p>
<p style="text-align: center;"><u>Stimulus Materials</u></p> <p>Graphic organizers, diagrams, graphs, data tables, drawings</p>	

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS3.C.2
Core Idea	Earth and Human Activity	
Component	Human Impacts on Earth's Systems	
MLS	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u>
<p>[Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> Examine the environmental impact of human water and land usage and pollution to design a method for monitoring and minimizing those impacts. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Human Impacts on Earth Systems</p> <ul style="list-style-type: none"> Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Cause and Effect</p> <ul style="list-style-type: none"> Through examination of environmental impacts of human water and land usage and pollution, a cause and effect relationship can be formed. <p>Influence of Science, Engineering, and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. 		<p>3</p> <p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

Content Limits/Assessment Boundaries

- Tasks should provide students with all needed background information and evidence.

Possible Evidence

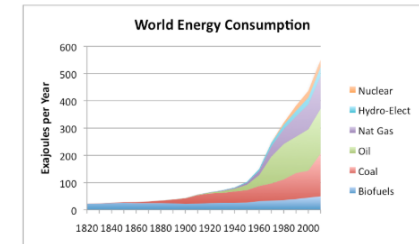
- Given a problem related to human impact on the environment, students use scientific information and principles to generate a design solution that
 - addresses the results of the particular human activity.
 - incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
- Students identify relationships between the human activity and the negative environmental impact based on scientific principles, and distinguish between causal and correlational relationships to facilitate the design of the solution.
- Students define and quantify, when appropriate, criteria and constraints for the solution, including
 - individual or societal needs and desires.
 - constraints imposed by economic conditions (e.g., costs of building and maintaining the solution).
- Students describe how well the solution meets the criteria and constraints, including monitoring or minimizing a human impact based on the causal relationships between relevant scientific principles about the processes that occur in, as well as among, Earth systems and the human impact on the environment.
- Students identify limitations of the use of technologies employed by the solution.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Sample Stems

Figure 1



<http://www.economywatch.com/economy-business-and-finance-news/did-malthus-get-it-right-after-all-27-12.html>

Figure 2

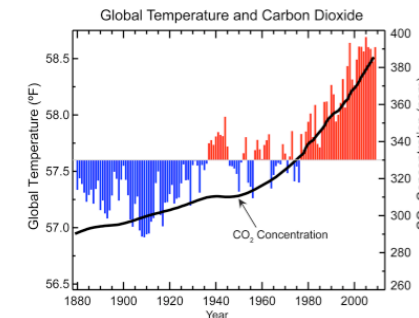
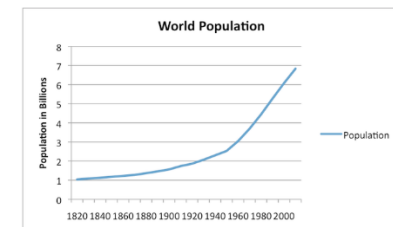


Figure 3



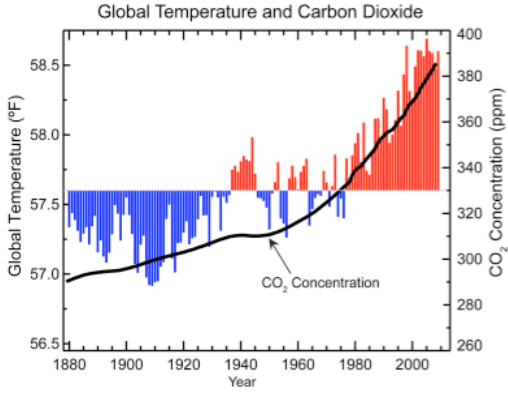
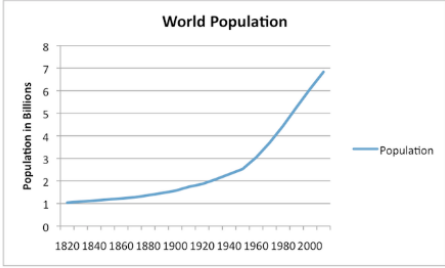
<http://www.economywatch.com/economy-business-and-finance-news/did-malthus-get-it-right-after-all-27-12.html>

1. Based on the data provided, describe one adjustment that can be made in order to lower the carbon dioxide emissions and thereby eventually lower global temperatures.

Grades 6-8 SCIENCE

Earth and Space Sciences		6-8.ESS3.D.1
Core Idea	Earth and Human Activity	
Component	Global Climate Change	
MLS	Analyze evidence of the factors that have caused the change in global temperatures over the past century.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<p>[Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]</p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Engaging in Argument from Evidence</p> <ul style="list-style-type: none"> Analyze evidence to identify factors that have caused changes in global temperatures over the past century. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Global Climate Change</p> <ul style="list-style-type: none"> Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding human behavior, and on applying that knowledge wisely in decisions and activities. <p><u>CROSSCUTTING CONCEPTS</u></p> <p>Stability and Change</p> <ul style="list-style-type: none"> Stability might be disturbed either by sudden events or gradual changes that accumulate over time. 		<p><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>

Grades 6-8 SCIENCE

<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should be limited to the interpretation of given data sets (e.g., temperature, carbon dioxide levels) 	<p align="center"><u>Sample Stems</u></p> <p>Figure 1</p> 
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> Students examine a given claim and the given supporting evidence as a basis for formulating questions. Students ask questions that would identify and clarify the evidence, including <ul style="list-style-type: none"> the relevant ways in which natural processes and/or human activities may have affected the patterns of change in global temperatures over the past century. the influence of natural processes and/or human activities on a gradual or sudden change in global temperatures in natural systems (e.g., glaciers and arctic ice, plant and animal seasonal movements, life cycle activities). the influence of natural processes and/or human activities on changes in the concentration of carbon dioxide and other greenhouse gases in the atmosphere over the past century. Student questions can be answered by examining evidence for <ul style="list-style-type: none"> patterns in data that connect natural processes and human activities to changes in global temperatures over the past century. patterns in data that connect the changes in natural processes and/or human activities related to greenhouse gas production to changes in the concentrations of carbon dioxide and other greenhouse gases in the atmosphere. 	<p>Figure 2</p>  <p>https://www.economywatch.com/economy-business-and-finance-news/did-malthus-get-it-right-after-all-27-12.html</p>
<p align="center"><u>Stimulus Materials</u></p> <p>Graphic organizers, diagrams, graphs, data tables, drawings</p>	<ol style="list-style-type: none"> <ol style="list-style-type: none"> Using the data provided, make a cause and effect statement between world population, global carbon dioxide, and global temperatures. What things are changing in each graph? Provide evidence which supports your claim in Part A.

Grades 6-8 SCIENCE

Engineering, Technology, and Application of Science		6-8.ETS1.A.1
Core Idea	Engineering Design	
Component	Defining and Delimiting Engineering Problems	
MLS	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	
<u>Expectation Unwrapped</u>		<u>DOK Ceiling</u> 3
<u>SCIENCE AND ENGINEERING PRACTICES</u> Asking Questions and Defining Problems <ul style="list-style-type: none"> Define a design problem that can be solved through the development of an object, tool, process, or systems. Takes into account the needs and limitations that arise based on relevant scientific principles and potential impacts on people and the environment. <u>DISCIPLINARY CORE IDEAS</u> Defining and Delimiting Engineering Problems <ul style="list-style-type: none"> The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. The specification of constraints includes consideration of scientific principles and other relevant knowledge that are limits to possible solutions. <u>CROSSCUTTING CONCEPTS</u> Influence of Science, Engineering, and Technology on Society and the Natural World <ul style="list-style-type: none"> All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and the limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. 		<u>Item Format</u> Selected Response Constructed Response Technology Enhanced
<u>Content Limits/Assessment Boundaries</u>		<u>Sample Stems</u>
<ul style="list-style-type: none"> Tasks should focus design constraints on time, materials, cost, and safety. Tasks should provide all needed formulas. 		Rock Port, Missouri was the first U.S. city to operate solely on wind energy. Wind energy is a renewable resource. Should Missouri invest more heavily in wind energy?

Grades 6-8 SCIENCE

Possible Evidence

- Students describe a problem that can be solved through the development of an object, a tool, a process, or a system.
- Students define criteria that must be taken into account in the solution that
 - meet the needs of the individuals or groups who may be affected by the problem (including defining who will be the target of the solution).
 - enable comparisons between different solutions, including quantitative considerations when appropriate.
- Students define constraints that must be taken into account in the solution, including
 - time, materials, and costs.
 - scientific or other issues that are relevant to the problem.
 - needs and desires of the individuals or groups involved that may limit acceptable solutions.
 - safety considerations.
 - potential effects on other individuals or groups.
 - potential negative environmental effects of possible solutions or failure to solve the problem.
- While defining the problem, students will
 - use systems and systems models.
 - examine cause and effect.
- Given a situation related to human impact on the environment, students use scientific information and principles to identify the problem that
 - address the results of the particular human activity.
 - incorporate technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
- Students identify relationships between the human activity and the negative environmental impact based on scientific principles and distinguish between causal and correlational relationships to facilitate the design of the solution.

Wind turbines work on a simple principle: instead of using electricity to make wind—like a fan—wind turbines use wind to make electricity. Wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity.

Wind is a form of solar energy caused by a combination of three concurrent events:

1. The sun unevenly heating the atmosphere
2. Irregularities of the earth's surface
3. The rotation of the earth.

To determine possible solutions, the first step is to determine the criteria and constraints of the problem.

Criteria

- 1.
- 2.
- 3.

Constraints

- 1.
- 2.
- 3.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Grades 6-8 SCIENCE

Engineering, Technology, and Application of Science		6-8.ETS1.B.1
Core Idea	Engineering Design	
Component	Developing Possible Solutions	
MLS	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	
<p align="center"><u>Expectation Unwrapped</u></p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Engaging in Argument from Evidence</p> <ul style="list-style-type: none"> Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. Evaluate design solutions using a systematic process to compare their abilities to meet the needs and address the limitations posed by a problem. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Developing Possible Solutions</p> <ul style="list-style-type: none"> There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <hr/> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>
<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should focus design constraints on time, materials, cost, and safety. Tasks should provide all needed formulas. 		<p align="center"><u>Sample Stems</u></p> <p>Wind turbines are a source of energy. There are three different designs of wind turbines explained below.</p>
<p align="center"><u>Possible Evidence</u></p> <ul style="list-style-type: none"> Students identify the given supported design solution. Students identify scientific knowledge related to the problem and each proposed solution. Students identify how each solution would solve the problem. Students identify and describe additional evidence necessary for their evaluation, including: <ul style="list-style-type: none"> knowledge of how similar problems have been solved in the past. evidence of possible societal and environmental impacts of each proposed solution. 		<p>Horizontal Axis Turbines</p> <p>Horizontal-axis wind turbines are what many people picture when thinking of wind turbines. Most commonly, they have three blades and operate "upwind," with the turbine pivoting at the top of the tower so the blades face into the wind.</p>

Grades 6-8 SCIENCE

- Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.
- Students use a systematic method (e.g., a decision matrix) to identify the strengths and weaknesses of each solution. In their evaluation, students
 - evaluate each solution against each criterion and constraint.
 - compare solutions based on the results of their performance against the defined criteria and constraints.
- Students use the evidence and reasoning to make a claim about the relative effectiveness of each proposed solution based on the strengths and weaknesses of each, given a situation related to human impact on the environment, students use scientific information and principles to identify the problem that
 - addresses the results of the particular human activity.
 - incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
- Students identify relationships between human activity and the negative environmental impact based on scientific principles and distinguish between causal and correlational relationships to facilitate the design of the solution.
- Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings



Vertical Axis Turbines

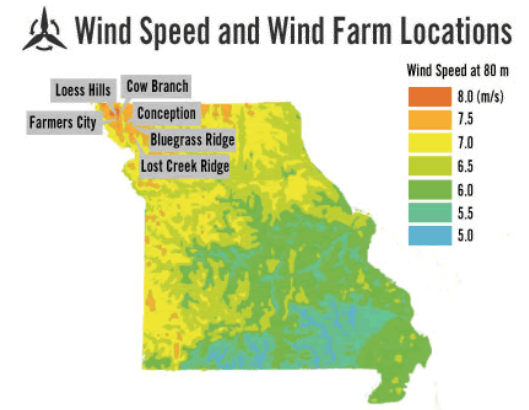
Vertical-axis wind turbines come in several varieties, including the eggbeater-style Darrieus model, named after its French inventor. These turbines are omnidirectional, meaning they don't need to be adjusted to point into the wind to operate.



Utility-Scale Wind Turbines

Grades 6-8 SCIENCE

Utility-scale wind turbines range in size from 100 kilowatts to as large as several megawatts. Larger wind turbines are more cost effective and are grouped together into wind plants, which provide bulk power to the electrical grid.



1. a. Identify which type of wind turbine would be best for south central Missouri.

b. Use evidence to support your answer to part A.

Grades 6-8 SCIENCE

Engineering, Technology, and Application of Science		6-8.ETS1.B.2
Core Idea	Engineering Design	
Component	Developing Possible Solutions	
MLS	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	
<p align="center"><u>Expectation Unwrapped</u></p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Analyzing and Interpreting Data</p> <ul style="list-style-type: none"> Analyze data from tests to compare and contrast design solutions for the purposes of combining the best components in a new solution to better meet the needs of the problem. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Developing Possible Solutions</p> <ul style="list-style-type: none"> There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. <p>Optimizing the Design Solutions</p> <ul style="list-style-type: none"> Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>
<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should focus design constraints on time, materials, cost, and safety. Tasks should provide all needed formulas. 		<p align="center"><u>Sample Stems</u></p> <p>Industrial scrubbers are devices that can control pollution by purifying the exhaust streams, which means that a minimal amount of harmful gases or particulates will leave the building and enter the environment. Below is a table comparing two types of scrubbers.</p>

Grades 6-8 SCIENCE

Possible Evidence

- Students organize given data (e.g., tables, charts, graphs) from tests intended to determine the effectiveness of three or more alternative solutions to a problem.
- Students use appropriate analysis techniques (e.g., qualitative or quantitative analysis, basic statistical techniques of data and error analysis) to analyze the data and identify relationships within the datasets, including relationships between the design solutions and the given criteria and constraints.
- Students use the analyzed data to identify evidence of similarities and differences in features of the solutions.
- Based on the analyzed data, students make a claim for which characteristics of each design best meet the given criteria and constraints.
- Students use the analyzed data to identify the best features in each design that can be compiled into a new (improved) redesigned solution.
- Students identify relationships between human activity and negative environmental impact based on scientific principles and distinguish between causal and correlational relationships to facilitate the design of the solution.
- Given a situation related to human impact on the environment, students use scientific information and principles to identify the problem that
 - address the results of the particular human activity.
 - incorporate technologies that can be used to monitor and minimize negative effects that human activities have on the environment.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Type	Advantages	Disadvantages
Wet	<ul style="list-style-type: none"> - collect particles and acid gases - cools hot gases - minimal explosion or fire hazard 	<ul style="list-style-type: none"> - produces liquid waste - high potential for corrosion - increase moisture loading into flue gas - high energy cost for fine particles
Dry	<ul style="list-style-type: none"> - produces dry product (ease of handling) - high efficiency for extremely small particles 	<ul style="list-style-type: none"> - risk of damage at high temperature - risk of dew at low temperatures - potential risk of fire and explosion

1. a. Identify the qualities that could be combined to produce the most effective and safe scrubber.
b. Use evidence from the data to support your answer to Part A.

Grades 6-8 SCIENCE

Engineering, Technology, and Application of Science		6-8.ETS1.B.3
Core Idea	Engineering Design	
Component	Developing Possible Solutions	
MLS	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	
<p align="center"><u>Expectation Unwrapped</u></p> <p><u>SCIENCE AND ENGINEERING PRACTICES</u></p> <p>Developing and Using Models</p> <ul style="list-style-type: none"> Develop a model to generate data to test ideas about designed systems including those representing inputs and outputs. Develop a model to generate data for repeated testing and modification of a proposed object, tool, or process for the purpose of the achievement of optimal design. <p><u>DISCIPLINARY CORE IDEAS</u></p> <p>Developing Possible Solutions</p> <ul style="list-style-type: none"> A solution needs to be tested and then modified on the basis of the test results in order to improve it. Models of all kinds are important for testing solutions. <p>Optimizing the Design Solution</p> <ul style="list-style-type: none"> The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. 		<p align="center"><u>DOK Ceiling</u></p> <p align="center">3</p> <hr/> <p align="center"><u>Item Format</u></p> <p>Selected Response Constructed Response Technology Enhanced</p>
<p align="center"><u>Content Limits/Assessment Boundaries</u></p> <ul style="list-style-type: none"> Tasks should focus design constraints on time, materials, cost, and safety. Tasks should provide all needed formulas. 		<p align="center"><u>Sample Stems</u></p> <p>Students design and build a windmill from the ground up to obtain maximum electrical output. Stock gear boxes, generator kits, etc. are not allowed.</p> <ol style="list-style-type: none"> Plan an investigation to determine which blade design is most effective to obtain maximum electrical output. Choose at least three designs from

Grades 6-8 SCIENCE

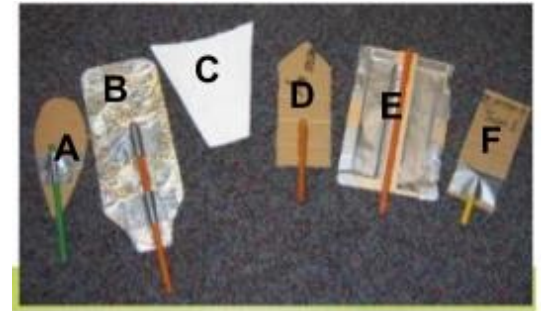
Possible Evidence

- Students develop a model in which they identify the components relevant to testing ideas about the designed system, including
 - the given problem being solved, including criteria and constraints.
 - the components of the given proposed solution (e.g., object, tools, or process), including inputs and outputs of the designed system.
- Students identify and describe the relationships between components, including the
 - relationships between each component of the proposed solution and the functionality of the solution.
 - relationship between the problem being solved and the proposed solution.
 - relationship between each of the components of the given proposed solution and the problem being solved.
 - relationship between the data generated by the model and the functioning of the proposed solution.
- Students use the model to generate data representing the functioning of the given proposed solution and each of its iterations as components of the model are modified.
- Students identify the limitations of the model with regard to representing the proposed solution.
- Students describe how the data generated by the model, along with criteria and constraints that the proposed solution must meet, can be used to optimize the design solution through iterative testing and modification.
- Given a situation related to human impact on the environment, students use scientific information and principles to identify the problem that
 - address the results of the particular human activity.
 - incorporate technologies that can be used to monitor and minimize negative effects that human activities have on the environment.
- Students identify relationships between the human activity and the negative environmental impact based on scientific principles and distinguish between causal and correlational relationships to facilitate the design of the solution.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

the ones pictured and determine how many blades you will use.



2. What will you measure as the response?
3. How will the data be used to inform the design?